FACT SHEET

Module 9 Stability Enhancement Systems

Stability Enhancement Systems

Today there are new technologies that are designed to help control your vehicle when you cannot. They are called intelligent stability and handling systems. Among the newest automotive safety advancements, they are now available on more and more vehicles as either optional or standard equipment. Some names for intelligent stability and handling systems that you may recognize are:

- Active Handling
- AdvanceTrac™
- Dynamic Stability Control
- Electronic Stability Program or ESP
- StabiliTrac
- Traxxar™

Stability Enhancement System Definitions

There are many automotive stability enhancement systems on the market today, with more arriving. These systems each have an acronym unique to their design, performance, or marketing features. Some of these names and acronyms are trade names of the system or vehicle manufacturers.

Currently Known Acronyms

Antilock Braking Systems, Traction Control Systems, Active Yaw Control Systems

- ABS ASC Active Brake
- (*Anti-lock Braking System*) (*Automatic Stability Control*)
- RWAL ASR Active Handling
- (*Rear Wheel Anti-lock*) (*Automatic Stability Regulation*)
- SCS Brake Only Traction Active Safety (*Stop Control System*)
- ETS (*Enhanced Traction System)* Advance Trac
- TCS (*Traction Control System*)
- ASMS (*Automotive Stability Management System*)
- TCB (*Traction with Brake Int.)* ATTS
- TRAC CBC (*Cornering Brake Control*)
- EDS DSC (*Dynamic Stability Control*)
- DTSC (*Dynamic Stability and Traction Control*)
- ESBS
- ESP (*Electronic Stability Program*)
- ICCS (*Integrated Chassis Control System*)
- IVD (*Integrated Vehicle Dynamics*)
- PCS (*Precision Control System*)
- PSM
- SCS (*Stability Control System*)
- StabiliTrac
- Traxxar
- VDC (*Vehicle Dynamics Control*)
- VSA (*Vehicle Stability Assist*)

- VSC (*Vehicle Stability Control*)
- YCS (*Yaw Control Stability*)

What Intelligent Stability and Handling Systems Do

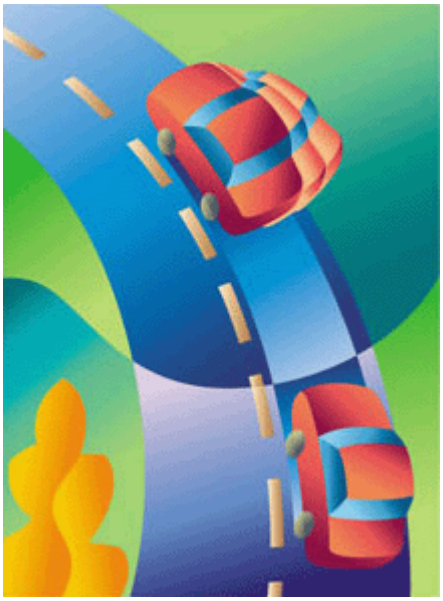
Intelligent stability and handling systems provide you with greater control of your vehicle when loss of control is imminent. They help you avoid obstacles and prevent the skidding that can occur in all kinds of weather and on all kinds of roads; conditions in which even the best of drivers might struggle to keep their cars on the road.

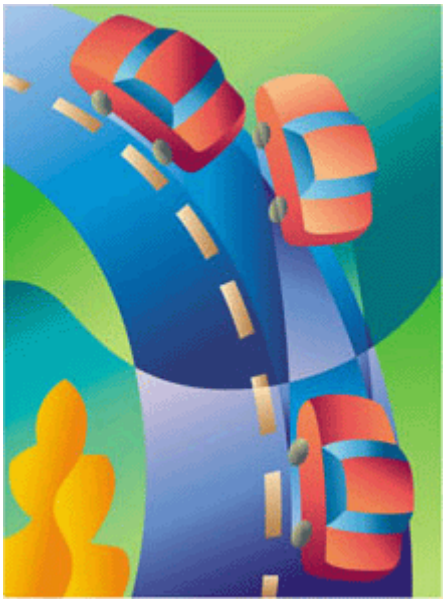
These systems have sensors that detect the direction your vehicle is going and compare it to the direction you are steering the vehicle. When the system detects a discrepancy between your intended path and the direction the vehicle is actually traveling, the system will intervene to help bring the movement of the vehicle back in line with your intentions.

Intelligent stability and handling systems intervene before control is lost by automatically braking specific wheels. In short, these systems help you maintain control when control might otherwise be lost.

When the rear wheels of a vehicle lose traction, oversteer can occur. When the front wheels lose traction, it's called under-steer. Either way, the driver can lose the ability to turn the car along the intended path.

When sensors in intelligent stability and handling systems detect oversteer is imminent, the outside front wheel brake is automatically applied to prevent loss of control.





Likewise, when the sensors detect under-steer is about to occur, they automatically brake the inside rear wheel, helping the driver make the turn and continue forward in the right direction.

System Descriptions

In this section, the minimum criteria of each system are listed. In addition, a brief description of atypical implementation and the advantages of each system are provided. This description is not intended to limit innovations such as development of alternate sensors, etc., but represents the current state of the art. In addition, it should be noted that performance of the systems might vary somewhat from manufacturer to manufacturer and from vehicle to vehicle as the systems are calibrated to satisfy the needs of a specific vehicle and target customer.

Antilock Braking Systems (ABS)

A system is identified as an Antilock Braking System if it:

- Is computer controlled.
- Has a means to determine if any wheel is about to lock.
- Has the capability of regulating the brake torque at the wheels to limit wheel lock.
- Controls the brake torque to each of the front wheels independently and the rear wheels either independently or as a pair.

ABS systems monitor the vehicle wheel speeds and regulate the brake forces to control the slip between the tire and the road surface. By avoiding wheel lock, vehicle stability is improved and the driver retains the ability to steer the vehicle. On most surfaces, the stopping distance of a vehicle with ABS is improved when compared to the same vehicle without ABS. Whether the rear wheels are controlled individually or as a pair depends on the specific characteristics of the vehicle, including load distribution and inherent vehicle stability, and the target market for the vehicle.

Rear Wheel Anti-lock (RWAL)

A system is defined as a Rear Wheel Anti-lock System if it:

- Is computer controlled.
- Has a means to determine if a rear wheel of the vehicle is about to lock.
- Has the capability of regulating the brake torque at the rear wheels to limit wheel lock.

RWAL systems monitor the vehicle's wheel speeds and limit the rear wheel brake torques to limit rear wheel lock-up. By avoiding rear wheel lock-up, the vehicle stability is improved. This system does not control the vehicle's front wheels and does not provide steering or stopping distance improvement.

Engine and Brake Traction Control Systems (EBTCS)

A system is defined as an Engine and Brake Traction Control System if it:

- Is computer controlled.
- Has a means to determine if a drive wheel is spinning.
- Has the capability of applying brake force individually to the drive wheels to limit wheel spin.
- Has the capability of controlling engine torque to reduce the brake torque needed to limit wheel spin.

Traction Control Systems monitor the wheel speeds and apply brake torques and/or control engine torque to the drive wheels as necessary to control spinning during acceleration. By controlling wheel spin, the vehicle stability, steerabililty and acceleration are improved. Also since the brakes can be applied to the drive wheels individually, engine torque can be transferred through the differential from one wheel to another. This can improve vehicle mobility and acceleration on surfaces that have non-uniform frictions (such as a condition where one drive wheel is on a slippery surface and another is on a higher-friction surface). The capability for controlling engine torque allows the system to minimize use of the brakes by reducing engine torque.

Brake Traction Control System (BTCS)

A system is defined as a Brake Traction Control System if it:

- Is computer controlled.
- Has a means to determine if a drive wheel is spinning.
- Has the capability of applying brake force individually to the drive wheels to limit spinning.

Brake Traction Control Systems monitor the wheel speeds and apply brake torque to the drive wheels as necessary to control spinning during acceleration. By controlling wheel spin, the vehicle stability, steerabilitly, and acceleration are improved. Also since the brakes can be applied to the drive wheels individually, engine torque can be transferred through the differential from one wheel to another. This can improve vehicle mobility and acceleration on surfaces that have non-uniform frictions (such as a condition where one drive wheel is on a slippery surface and another is on a higher-friction surface.) Since the Brake Traction Control Systems do not have the capability of reducing engine torque, the duration of their activation must be limited, especially at high speeds. These systems may be deactivated at high speeds and may include algorithms to estimate brake temperatures and disable the system if the temperatures exceed some limit.

Engine Only Traction Systems (ETS)

A system is defined as an Engine Only Traction System if it:

- Is computer controlled.
- Has a means to determine if a drive wheel is spinning.
- Has the capability of controlling engine torque to limit wheel spin.

Engine Only Traction Systems monitor vehicle wheel speeds to determine if a drive wheel is spinning during acceleration, and reduce engine torque to control spinning. Controlling wheel spin can improve vehicle stability, steerability, and acceleration capability.
No brake applications are used with this system, and it does not have any ability to transfer torque from one wheel to another.

Active Yaw Control Systems (AYC)

A system is defined as an Active Yaw Control System if it:

- Is computer controlled and the computer contains a closed-loop algorithm designed to limit understeer and oversteer of the vehicle.
- Has a means to determine vehicle yaw velocity and side slip.
- Has a means to monitor driver steering input.
- Has a means of applying and adjusting the vehicle brakes to induce correcting yaw torques to the vehicle.
- Is operational over the full speed range of the vehicle (except below a minimum speed where loss of control is unlikely).

Active Yaw Control Systems in use today can be divided into four categories:

Four Wheel AYC Systems with Engine Control:

- This system must have the means to apply all four brakes individually and a control algorithm which utilizes this capability.
- The system must have an algorithm to determine the need, and a means to modify engine torque, as necessary, to assist the driver in maintaining control of the vehicle.
- The system must be operational during all phases of driving including accelerating, coasting, and decelerating (including braking).
- The system must stay operational when ABS or Traction Control are activated.*

Four Wheel AYC Systems without Engine Control:

- This system must have the means to apply all four brakes individually and a control algorithm which utilizes this capability.
- The system must be operational during all phases of driving including accelerating, coasting, and decelerating (including braking).
- The system must stay operational when ABS or Traction Control are activated.*

Two Wheel AYC Systems with Engine Control:

- This system must have the means to apply all four brakes individually and a control algorithm which utilizes this capability.
- The system must have an algorithm to determine the need and a means to modify engine torque, as necessary, to assist the driver in maintaining control of the vehicle.
- The system must be operational during all phases of driving including accelerating, coasting, and decelerating (including braking).
- The system must stay operational when ABS or Traction Control are activated.*

Two Wheel AYC Systems without Engine Control:

- This system must have the means to apply all four brakes individually and a control algorithm which utilizes this capability.
- The system must be operational during all phases of driving including accelerating, coasting, and decelerating (including braking).
- The system must stay operational when ABS or Traction Control are activated.*
- **Some systems may have limited Yaw Control performance during ABS or Traction Control activation.*

All Active Yaw Control Systems are assumed to include ABS. The vehicles may also include other brake-related or stability enhancement features such as:

Traction Control to control wheel spin during acceleration.

- Dynamic Brake Proportioning to control the vehicle front/rear brake balance.
- Engine Drag Control to prevent excessive wheel slip due to throttle lift-off or down shifting.
- Other computer-controlled features which can activate or modify vehicle braking.
- Other computer-controlled stability enhancement features.

If any of these features is included on the vehicle, the Active Yaw Control System must be capable of coordinating their activities to aid the driver in maintaining control of the vehicle and to prevent undesirable interactions.

Active Yaw Control Systems use various sensors (typically wheel speed sensors, steering angle sensors, yaw rate sensors, and accelerometers) to monitor the dynamic state of the vehicle and the driver's commands. They then apply the vehicle's brakes (and adjust engine torque) to make appropriate adjustments to the rotational movement about the vehicle's vertical axis and correct the path of the vehicle to the driver's intended path.

These systems improve the vehicle's stability, the driver's control of the vehicle, and correct understeer and oversteer conditions that occur. The type of Active Yaw Control used on a specific vehicle is the decision of the vehicle manufacturer. Factors affecting this decision may include handling characteristics of the vehicle, vehicle weight distribution, powertrain size and type, intended vehicle use, size, cost, and targeted customer.

Other Stability Enhancement Features

While the emphasis of today's Yaw Control Systems is placed on control of the brake forces, the broader objective of such systems is to control the forces between the tire and the road by any actuation mechanism. In addition to the brakes, other systems are capable of effecting the wheel forces and thereby influencing the vehicle's dynamic behavior.

These systems include the suspension, steering, and drivetrain. Controlled suspension systems have the ability to manage vertical wheel loads and thus influence the longitudinal and lateral force capability of each tire. The actuation may be through the active control of any or all of the following:

- Damping coefficients.
- Spring rates.
- Anti-roll bar rates.
- Other suspension components.

Controlled steering systems have the ability to actively adjust the steered angle or the camber angle of any or all of the wheels to influence the longitudinal and lateral forces of the tire.

Drivetrain controls have the ability to adjust the engine torque applied to each of the wheels to influence the longitudinal and lateral forces of the tire. This may be accomplished by a combination of engine torque adjustment and control of differentials to manage the torque across axles.

Integrated Vehicle Systems:

[Vehicle Dynamics Control (VDC), Integrated Chassis Control System (ICCS), Electronic Stability Programs (ESP), Dynamic Stability Control (DSC)]

These systems combine vehicle stability features such as ABS, Traction Control, Electronic Brake Distribution (Dynamic Rear Proportioning), Active Yaw Control Systems, Suspension Controls, and Steering Controls on one vehicle. Each manufacturer may package and name these combinations to suit their specific vehicle and customer. These names may be trademarks of individual manufacturers.

Discussion

The advent of the automotive microprocessor and sensor technologies has made possible an array of electronically controlled vehicle stability enhancement systems. These systems have the capability of applying or regulating the brake force at the wheels to influence the stability and/or steering and handling of the vehicle. In addition, many of the systems have interfaces with the powertrain, suspension, steering, and other vehicle systems to further enhance their control capability.

Each of these systems is designed to optimize use of the friction at the tire/road interface. Since the friction between these patches of tire and the road surface is the force which allows the vehicle to accelerate, decelerate, and turn, optimization of this force provides the opportunity to enhance vehicle stability and handling. Some of these systems, such as ABS, have widespread application in the market and already are contributing to improved handling and control of vehicles.

Others, such as Active Yaw Control, are beginning to penetrate the market and demonstrate their benefits in assisting the driver and making further contributions to vehicle safety. As these systems have been developed, each manufacturer has included its own features and in many cases has marketed them under their own name. In some cases this has caused confusion in the industry. In some cases, different systems may have been called the same or very similar names, and in other cases, similar systems have been referred to by different names.

Some differentiation between manufacturers will continue to exist, and manufacturers will continue to market features or combinations of features under their own names. The definitions outlined here provide a baseline set of agreed upon definitions to avoid confusion, to represent the current state of the art, and provide building blocks for further development.

Conclusions

Over the past several years, engineers at the motor vehicle manufacturers and their suppliers have developed an array of stability enhancement systems. These systems are computer controlled and use various sensors to monitor vehicle parameters. They improve the vehicle stability and handling by optimizing the use of the friction between the tires of the vehicle and the road surface.